I/ITSEC Tutorial

Return on Investment (ROI) for Modeling and Simulation

Dr. Edward Degnan
Division Chief, M&S Foundations Division
407-208-5779, DSN 970,
edward.degnan@afams.af.mil

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Tutorial Objective

This tutorial will present Return-on-Investment (ROI) concepts and processes that can be used to determine the ROI of a model or simulation in any functional area by enabling the student to:

- **apply ROI terms, guidelines and formulas to their own M&S projects**
- **evaluate all costs / resources associated with an M&S program**
- **identify alternative methods of achieving goals**
- **calculate the ROI of an M&S program based on quantitative and qualitative criteria**

Tutorial Outline

1. Introduction to Return-on-Investment
1.1. What Is ROI and Why Is It Important?
1.2. ROI for Modeling and Simulation

2. Process for Quantifying M&S
2.1. Requirements Definition
2.2. Nine ROI Factors for M&S

3. Evaluating an M&S Application
3.1. Designing Metrics for the Nine Factors
3.2 Functional Implications of the Nine Factors
3.2.1. Quantitative Metrics
3.2.2 Qualitative Metrics

M&S – Negative or Positive ROI?

Simulation and acquisition programs (that used M&S) failures have raised concerns about why these investments so often fail to live up to expectations.

M&S during Vietnam

Crusader

Comanche

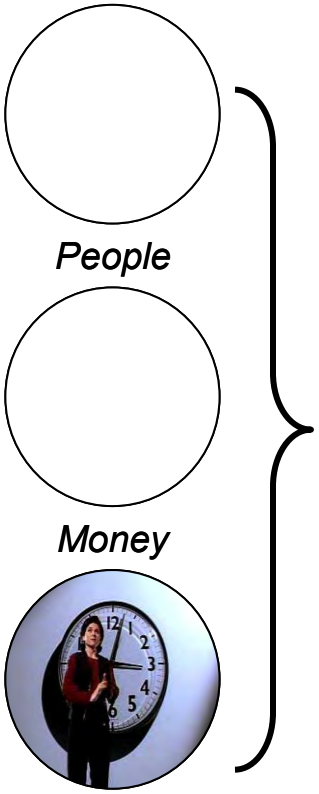
M&S in the Gulf War Casualties Count

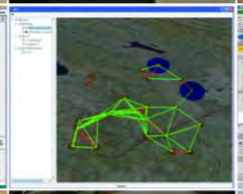
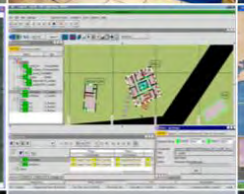
Rise and Fall of JSIMS

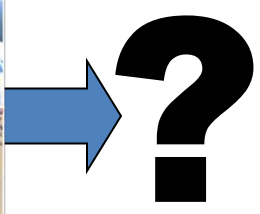
What is ROI?

A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments.

Investment | **Alternative(s)** | **ROI**



	Individual	Individual On Individual	Small Organization	Multiple Organization
Virtual Simulation				
Constructive Simulation				
Live Simulation				



http://dictionary.reference.com/browse/ROI

Why Should I Care about ROI?

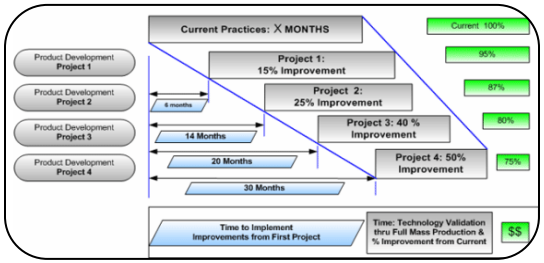
Justifies the investment to decision makers

Provides justification for oversight of funding the investment throughout its life cycle

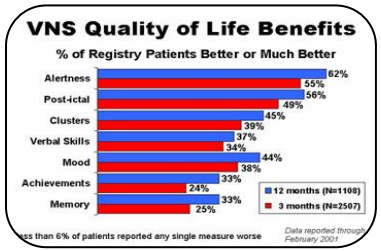
Establishes a baseline to monitor, measure and evaluate the investment

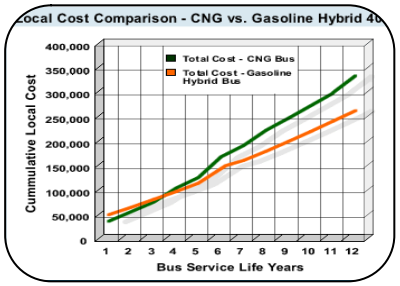
Questions for an ROI Analysis

Effectiveness: How much —bang for the buck" will we get out of this project?



Impact: Will the benefits to USAF, DoD, federal government, country or society justify the overall investment in this project?





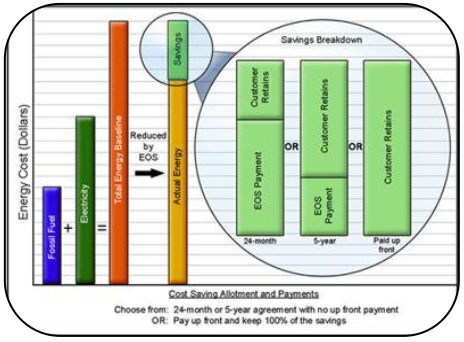
Questions for an ROI Analysis

Efficiency: Is this the most we can get for this much investment?

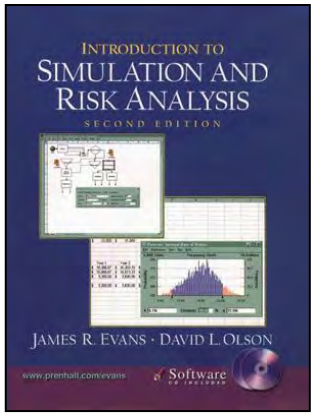
Alternatives to Bluetooth

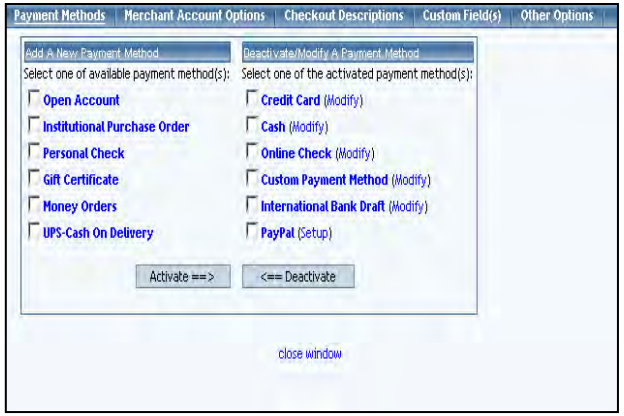
	Bluetooth	HomeRF	IEEE 802.11b (Wi-Fi)	IrDA
Primary Use	Cable replacement and ad hoc device-to-device connections	Home or small office LANs	Corporate or campus LANs	Cable replacement and ad hoc device-to-device connections (narrow angle)
Max Speed	1 Mbps	10 Mbps	11 Mbps	4 Mbps
Range	30 feet	150 feet	300 feet	3 feet
Through walls	Yes	Yes	Yes	No
Requires base station	No	No	Yes	No
Interference susceptibility	Medium	Medium	High	None
Power Reqs	Low	High	High	Low
t to build	$8 now	$70-$120	$100-$300	$2

Financial: Can we afford this? Will it pay for itself?



Conducting an ROI Analysis





ROI a rather diverse collection of methods, skills, tools, activities and ideas.

No single —right" way to conduct a ROI analysis.

ROI is not a silver bullet - nor is there a Consumer Report for ROI products and services.

Design Metrics

Remember the perspective of who the ROI is for.

Internal to the Program

Program Manager

Using Organizations

User

External to the Organization

Press

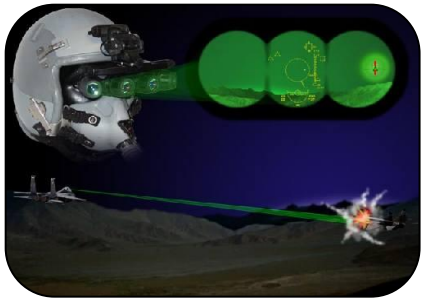
Other

Environmentalist

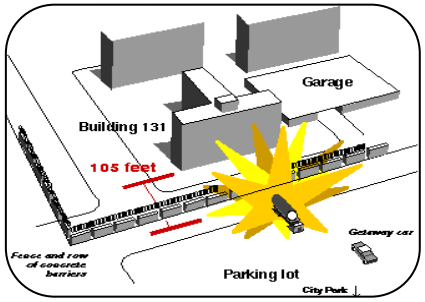
Areas for M&S Return on Investment

Reuse

Readiness



Efficiency



Risk Reduction

Effectiveness

Money

Environment

Lives

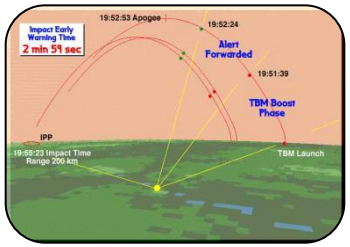
Time

Areas for M&S Return on Investment

Reuse

Extended Air Defense Simulation (EADSIM)

First Deployed in 1989



Used by:

- Combat developers
- Materiel developers
- Operational commanders

Interfaces:

- Aggregate Level Simulation Protocol (ALSP)
- Distributed Interactive Simulation (DIS)
- High Level Architecture (HLA)

EADSIM used during DESERT SHIELD/DESERT STORM:

- To analyze attrition, Suppression of Enemy Air Defense (SEAD) missions and refueling operations
- BGen Glosson stated that EADSIM "saved lives and equipment."
- 32nd Army Air Defense Command used EADSIM to analyze proper positioning of PATRIOT in Israel and Turkey

EADSIM is now being used at more than 390 subscriber sites around the world.

http://www.smdc.army.mil/FactSheets/EADSIM.pdf

Areas for M&S Return on Investment

Readiness

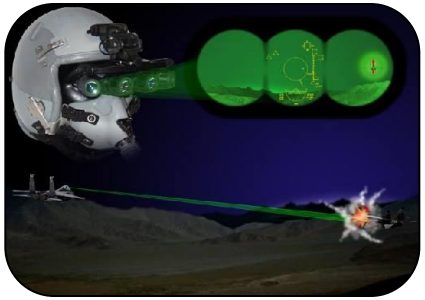
B2 Bomber

- Limited Number of Aircraft – 21 Operational (1 Test)
- Operation Construct – Stateside Basing
- Construct Leads to Long Missions

- Longest Single Sortie was 44 hours
- Crew – 2 Pilots
- Cost to Fly Aircraft
- Train via Simulation

"B2 pilots' greatest challenge is endurance… in training they spend as long as 50 hours in simulators." Maj Gen Przybyslawski

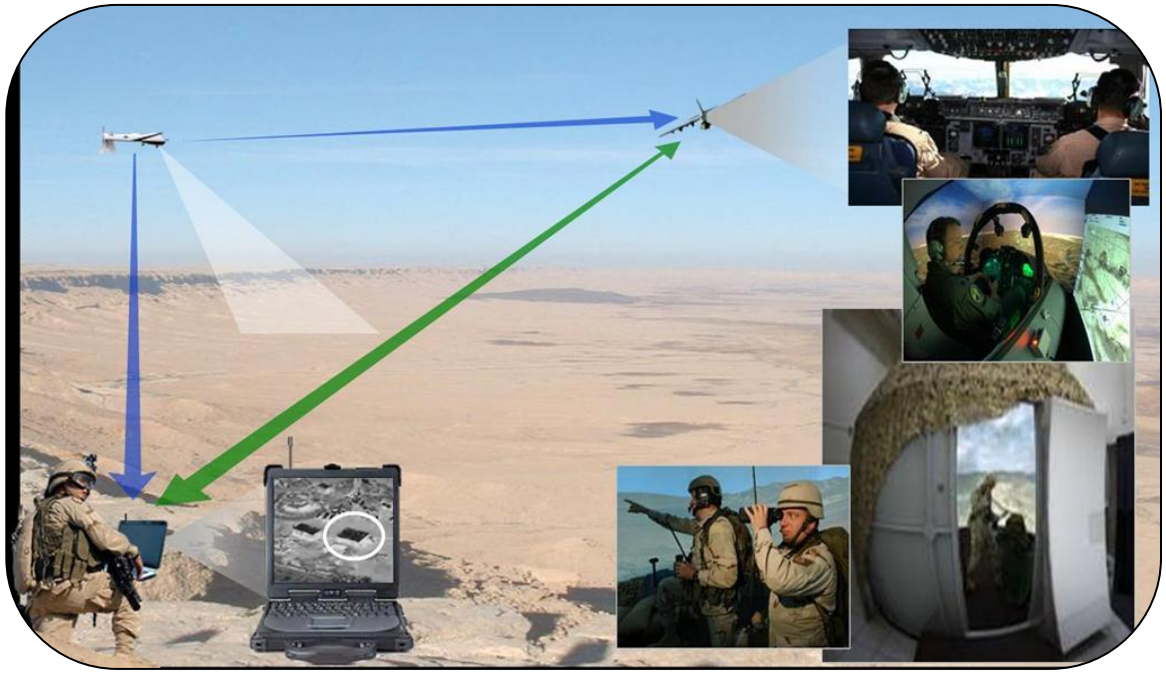
Areas for M&S Return on Investment



Efficiency

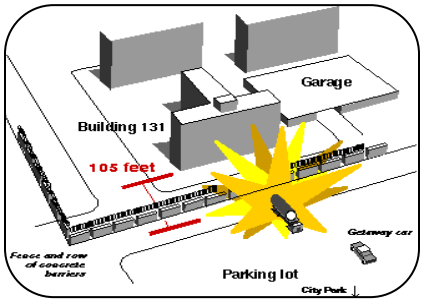
Predator

ROVER
Remote Operations Vehicle Enhanced Receiver



Provides Joint Terminal Air Controller (JTAC) with Predator video to provide terminal attack control without direct eyes on target

Areas for M&S Return on Investment



Risk Reduction

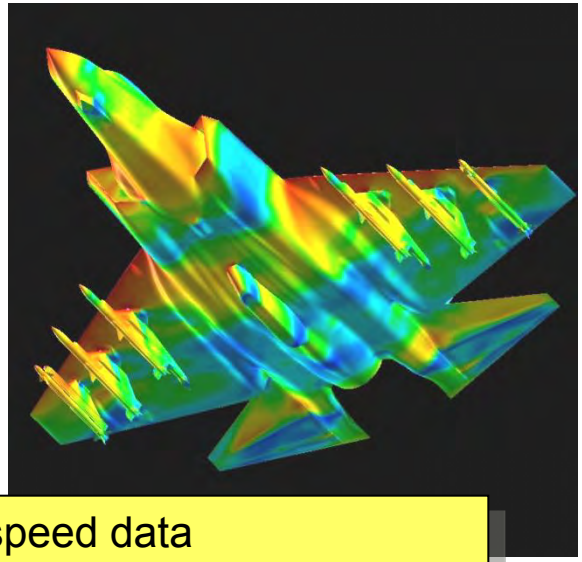
Jet Blue

—That is a very difficult maneuver, especially since pilots are not given simulator time to practice it. As of Monday this event will be part of simulator training."

http://www.airlinesafety.com/editorials/JetBlueLAX.htm

Areas for M&S Return on Investment

Joint Strike Fighter Applications
Arnold Engineering
and Development Center



Effectiveness

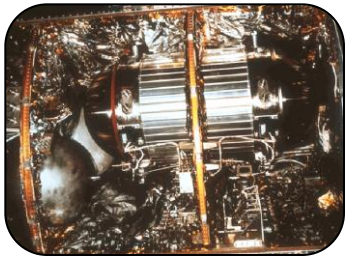
- **Wind Tunnel Effects**
- **Airframe Loads**
- **Carriage Loads**
- **Store Separation**
  - **Internal Carriage**
  - **External Carriage**
- **Fuel Tank**
  - **Design**
  - **Loads**
  - **Jettison**
- **Aircraft lift fan/secondary inlet design**

- Eliminated tests for high speed data
- Improved data quality and reduced risk
- Computed trajectories beyond tunnel hardware movement constraints
- Screened test configurations, reducing testing costs
- Total savings = $ Millions

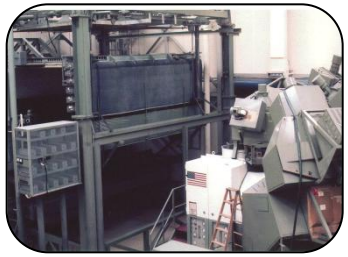
http://www.afmc.af.mil/news/story.asp?id=123018039

Areas for M&S Return on Investment

Lives



- **Oxygen tank No. 2 blew up**
- **Command modules normal supply of electricity, light & water was lost**
- **200,000 miles from Earth**



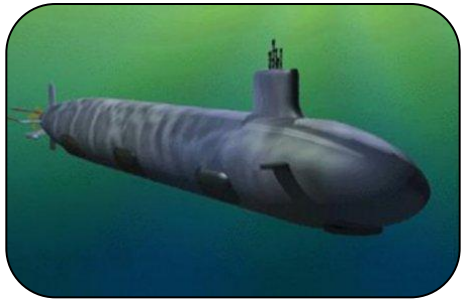
- **New procedures had to be written and tested**
  - **A coast-to-coast network of simulators, computers and experts was formed**
  - **Everything was tested in the simulator before being passed up to the crew**

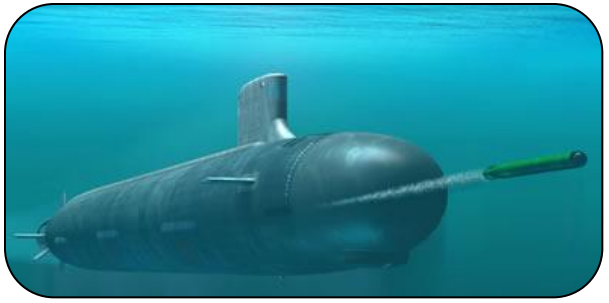
http://liftoff.msfc.nasa.gov/Academy/History/APOLLO-13/MISSION-REPORT.HTML

Areas for M&S Return on Investment

Time

Virginia Class Submarine





Electric Boat, by using M&S, took 7 years off development of the submarine.

http://www.defense-update.com/newscast/0107/news/010107_virginia.htm

Areas for M&S Return on Investment

Money

Air Mobility Command (AMC)

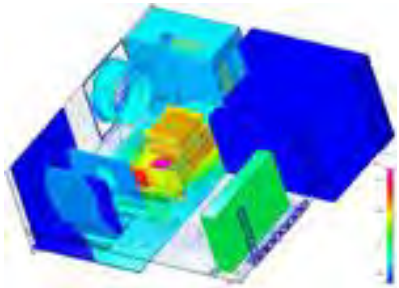
- Invested $1.4 billion to purchase additional simulators and upgrade existing ones.
- Estimates aircraft flight hours will be reduced by 270,000 hours over the next 6.5 years.
- Save $2.3 billion in aircraft fuel, airframe use, wear and tear and aircraft maintenance.

http://www.amc.af.mil/news/story.asp?id=123031427

Areas for M&S Return on Investment

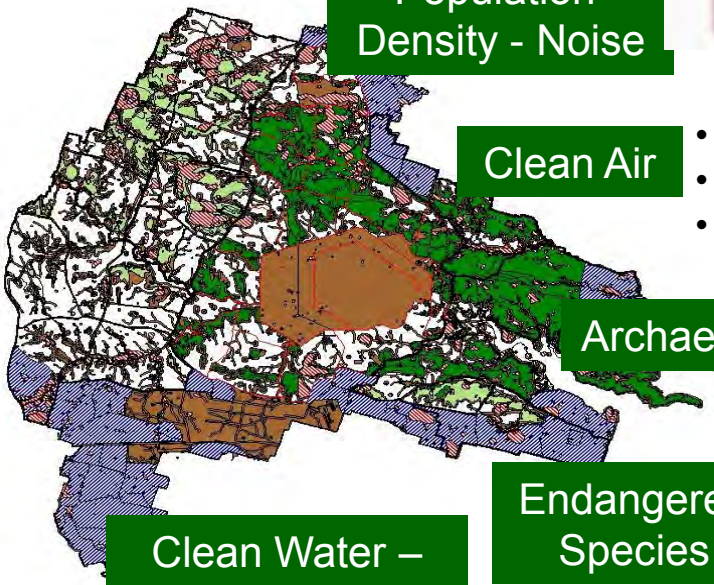
Due to restrictions, weapons or testing threats are prohibited.

Defense Threat Reduction Information Analysis Center



Environment

Population Density - Noise



Clean Air

Archaeology

Endangered Species

Clean Water – Erosion Control

Ft Hood Environmental Restrictions

- **199,541 total land**
- **154,053 acres with training restrictions - 77% of training land**
- **30,827 acres of maneuver land without training restrictions**

GAO-02-727T Military Training

Encroachment had affected every training range's capabilities, requiring work-arounds—or adjustments to training events. A more complete assessment of training resources should include assessing the potential for using virtual or constructive simulation technology to augment live training.

http://www.gao.gov/htext/d03621t.html

Areas for M&S Return on Investment

 Reuse	 Efficiency	 Readiness	 Lives	 Risk Reduction	 Effectiveness	 Time	 Money	 Environment
Training								
Increase # of users and applications for the simulation	Proficiency level after a simulation event	Increased preparedness to a greater number of situations	Reduced deaths & injuries through simulations	Reduced accidents during high-risk training	Increased performance in real-world situation	Optimize training for the audience	Optimize or reduce the cost of training	Use simulation for training that can not be done
Acquisition								
Increase # of users and applications for the simulation	Lower cost due to simulation use	Faster delivery of new materials to the warfighter	Simulation testing prior to human conducting live testing	Remove more of the unknowns in the testing cycle	Able to, as a minimum, keep project on time and budget	Maintain or reduce development time	Maintain or reduce acquisition costs	Offset restrictions caused by environment constraints
Analysis								
Increase # of users and applications for the simulation	Greater accuracy based on the use of a simulation	Increase the timeliness of analytical information	Removing some areas of human error prior to decisions	Look at larger number of what ifs	Fill in void when subject matter experts are unavailable	Provide answers faster	Reduce costs for development of analytical products	Analyze situations that can not be done live

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Collect Data

Analyze Data

Determine ROI

If Needed, Initiate Corrective Action

Adjust Throughout the Process!

Process for Quantifying M&S

Determine Requirements

Document the Process and Results!

Adjust Throughout the Process!

Determine Requirements
Describe the Problem

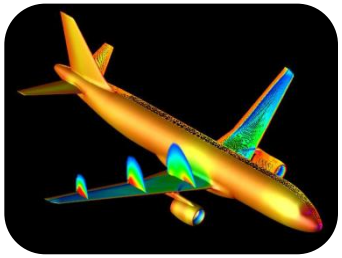
Crisis Management Issues - Example

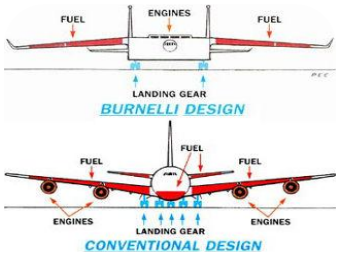
Within the United States civilian and military aviation system there are numerous crisis situations that occur each year that receive both local and national attention.

Determine Requirements Example – Perspective Implications

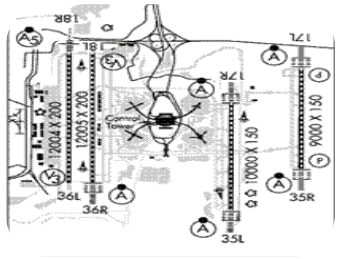
Training Example – How do I prepare employees for an aviation incident /accident?

Acquisition Example – How do I design a safer aircraft?





Analysis Example – How do I react in the event of a crisis at an airport?



Determine Requirements Example – Identify Users

Training Users

Acquisition Users

Analysis Users

Determine Requirements Example – Describe the Problem

Training Example – How do I prepare employees for an aviation incident /accident?

Pilot

Flight Attendant

Ground Crew

TSA

Ground Controller

Air Traffic Controller

Local Medical Responders

On Site Responders

Ticket Agents

Local SWAT Teams

Local Police Aviation

Medevac Teams

Aircraft crew members need to recognize, evaluate and respond to emergency situations on an aircraft with an appropriate crew resource management course of action.

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

→ Set Standards of Performance

Adjust Throughout the Process!

Standards of Performance



The manner in which something or somebody functions, operates or behaves in terms of established criteria



Standards of Performance Example

Training Example – How do I prepare employees for an aviation incident /accident?

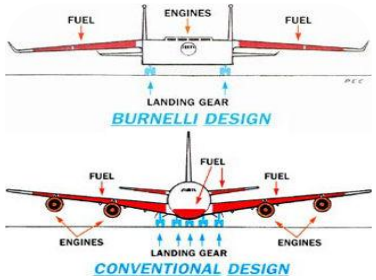


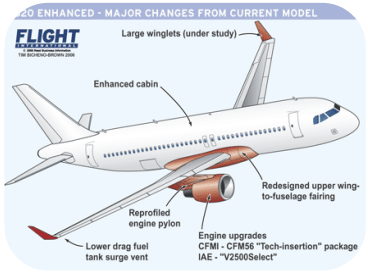
IX. AREA OF OPERATION: EMERGENCY OPERATIONS

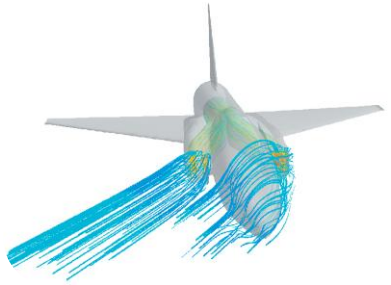
A. TASK: EMERGENCY APPROACH AND LANDING - (ASEL and ASES) REFERENCES: FAA-H-8083-3; POH/AFM.
Objective. To determine that the applicant:
1. Exhibits knowledge of the elements related to emergency approach and landing procedures.
2. Analyzes the situation and selects an appropriate course of action.
3. Establishes and maintains the recommended best glide airspeed, ±10 knots.
4. Selects a suitable landing area.
5. Plans and follows a flight pattern to the selected landing area considering altitude, wind, terrain, and obstructions.
6. Prepares for landing, or go-around, as specified by the examiner.
7. Follows the appropriate checklist.

Standards of Performance Example

Acquisition Example – How do I design a safer aircraft?







The FAA provides the following categorizations of aircraft.
1.Categorization by Stall Speed (which determines the basis of landing or approach speed): Table 1 - Aircraft Approach Category Source: FAA, 1976, United States standards for Terminal Instrument Procedures, 3d ed, FAA Handbook 8260.3B)

Aircraft Category	1.3 Times the Stall Speed in Knots	Maximum Speed (Circling Approaches)	Typical Aircraft in This Category
A	less than 91 knots	90 knots	small single engine
B	91 to 120 knots	120 knots	small multi engine
C	121 to 140 knots	140 knots	airline jet
D	141 to 165 knots	164 knots	large jet/military jet
E	above 166 knots		special military

Standards of Performance Example

Analysis Example – How do I react in the event of a crisis at an airport?

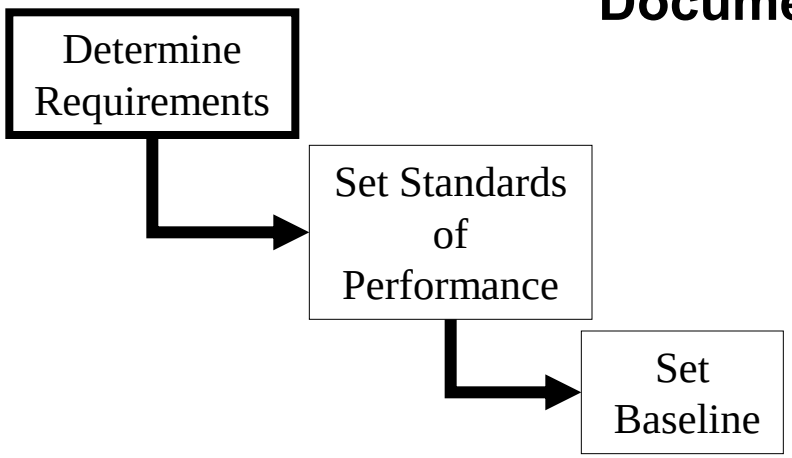
• Current FAA standards for rescue and firefighting equipment are included in both FARs and Advisory Circulars.

• Aircraft rescue and firefighting indexes are, in accordance with FAR Part 139.315, designated by an index letter (i.e., A, B, C, D, or E) that represents the size of the largest aircraft the airport is prepared to handle in the event of a fire or rescue situation.

• Part 139.315 further states that —if there are five or more average daily departures of air carrier aircraft in a single index group, the longest index group with an average of 5 or more daily departures is the index required for the airport. In addition, if there are less than five average daily departures of air carrier aircraft in a single index group serving that airport, the next lower index from the longest index group with an air carrier aircraft in it is the index required for the airport."

Process for Quantifying M&S

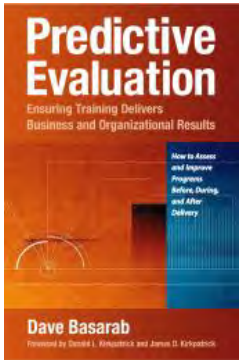
Document the Process and Results!



Adjust Throughout the Process!

Baseline

Conducted prior to the beginning of the event.
Point of comparison for monitoring and evaluation data.



Focuses on the intended outcomes of a project.

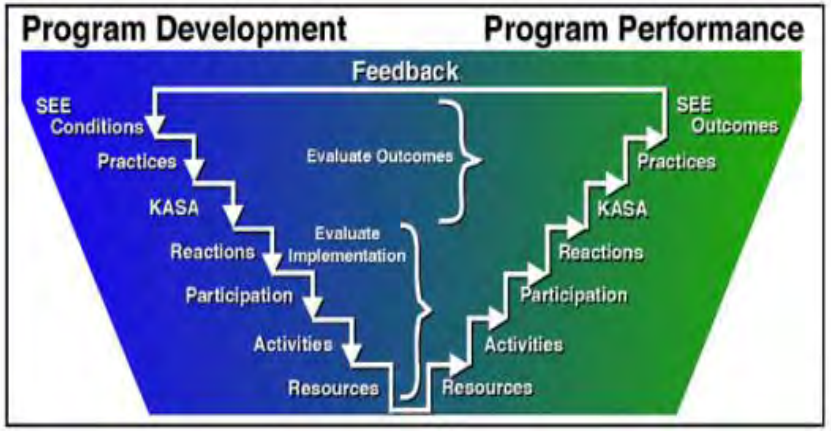
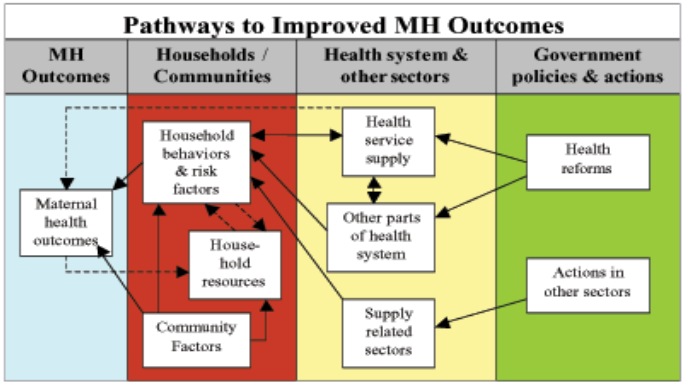


Figure 1: *Pathways to Improved Maternal Health Outcomes*



Source: PRSP Sourcebook, Claeson, et al.

Accounts for secondary outcomes and assumptions.

Baseline Example

Training Example – How do I prepare employees for an aviation incident /accident?

Collect information on the current state of formal and informal training or education for employees who would deal with an **aviation incident /accident**.

Conduct interviews to gather information to benchmark the levels of knowledge, experience and training for each individual.

Conduct a qualitative survey on individual perception of being prepared for an **aviation incident /accident**.

Baseline Example - Survey

National Aviation Operations Monitoring Service (NAOMS)
NASA Airline Study

- **Air Carrier Questionnaire: Section B – Safety Events"**

- **Aircraft mechanical & equipment (ER1-ER7) maintenance, equipment failures, fire, smoke**

- **Turbulence: Wake and en route (TU1-TU2):**
  - **Weather (WE1-WE6) Icing, diversions, ATC Wx issues & windshear**
  - **Passenger-Related Events (CP1-CP3) Disruption, medical emergency**
  - **Airborne Conflicts (AC1-AC3) Bird strikes, NMACs**
  - **Ground Events (GE1-GE10) Near collisions, hydroplaning, off runway events**

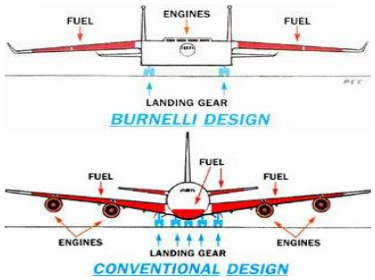
- **Aircraft handling (AH1-AH15) Variety of pilot-related issues:**
  - **Overweight, stalls, unusual attitudes, tail strikes, etc.**
  - **Altitude Deviations (AD1-AD2) Descend below MSA, deviation from assigned altitude**
  - **Air Traffic Control (AT1-AT2) Difficulty contacting ATC, high & fast clearances**

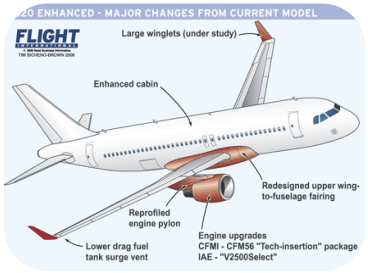
Baseline Example – Survey Results

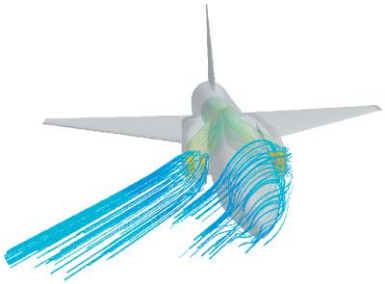
1) Engine/Nacelle smoke/fire/fumes involving electrical components/wiring
2) Smoke, fire or fumes originated in cargo/baggage area
3) Cargo/baggage smoke/fire/fumes involving electrical components/wiring
4) Passenger compartment smoke/fire/fumes involving electrical components/wiring
5) Flights/attempted flights with wrong type of fuel
6) Severe turbulence resulting in occupant injury
7) Airplane went off end of runway
8) Hit/collided with runway/taxiway lights
9) Hit animal other than bird
10) Collided/nearly collided with ground vehicle on ramp/apron
11) Nearly collided [with another aircraft] while on runway
12) Began takeoff without ATC clearance at airport with active control tower
13) Near collision [with terrain or ground obstruction while airborne]
14) Airplane crossed runway threshold during landing approach with gear up
15) Airplane landed with gear up

Baseline Example

Acquisition Example – How do I design a safer aircraft?







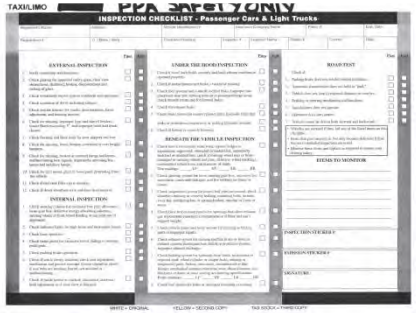
Accident Reports

OSHA Studies

Aviation Incident Reports

Baseline Example

Analysis Example – How do I react in the event of a crisis at an airport?



Reports

Previous Studies

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Adjust Throughout the Process!

Simulation Application Requirement

United States General Accounting Office
GAO Report to Congressional Requesters

November 1997 HUMAN FACTORS
FAA's Guidance and Oversight of Pilot Crew Resource Management Training Can Be Improved

GAO/RCED-98-7

Of 169 accidents examined, 30 percent were caused in part by the pilots' performance. Pilots incorrectly used the principles of Crew Resource Management (CRM) - an approach to improving safety through coordination of the cockpit crew, flight attendants, dispatchers and air traffic controllers.

Requirement *- Train pilots and crew in CRM*

Baseline *- Results from GAO report*

Standard *- Reduce percentage of accidents due to CRM*

M&S Application *- Train pilots & crew in CRM through simulation*

Determine Requirements
Example – Who is the CRM Audience?

Training Example – How do I prepare employees for an aviation incident /accident?

Pilot

Flight Attendant

Ground Crew

TSA

Ground Controller

Air Traffic Controller

Local Medical Responders

On Site Responders

Ticket Agents

Local SWAT Teams

Local Police Aviation

Medevac Teams

Aircraft crew members need to recognize, evaluate and respond to emergency situations on an aircraft with an appropriate crew resource management course of action.

Determine Requirements
Example – Who is the CRM Audience?

Training Example – How do I prepare employees for an aviation incident /accident?

Pilot

Flight Attendant

Ground Controller

Air Traffic Controller

Aircraft crew members need to recognize, evaluate and respond to emergency situations on an aircraft with an appropriate crew resource management course of action.

Design M&S Application Training Example

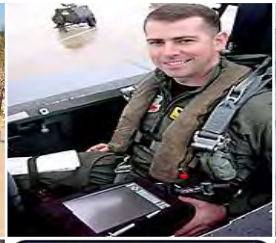
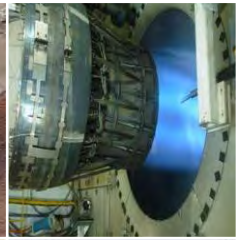
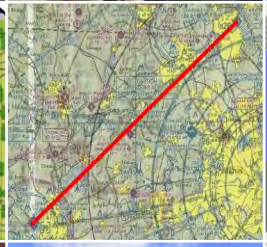
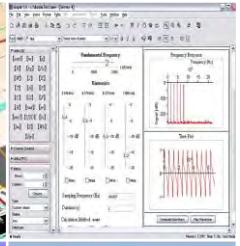
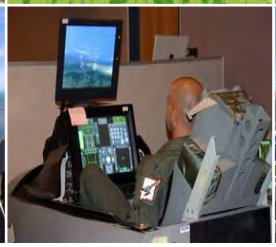
Two Components of the Simulation

Realistic Scenario

True Physical Environment

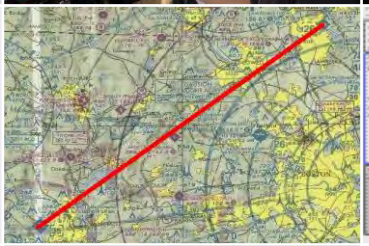
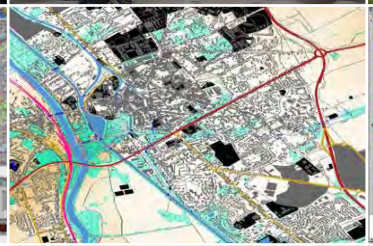
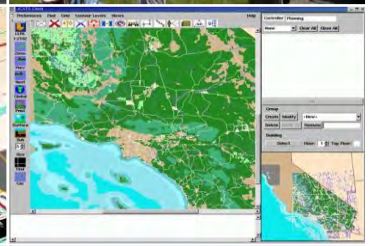
Simulation Application Options

Establish Alternatives

	Acquisition	Training	Education	Planning	Experimentation	T&E
Live Simulation						
Constructive Simulation						
Virtual Simulation						

Simulation Application Options

Establish Alternatives

	Individual	Individual to Individual	Small Organization	Multiple Organizations
Live Simulation				
Constructive Simulation				
Virtual Simulation				

Design M&S Application

Crisis Management Issues - Example

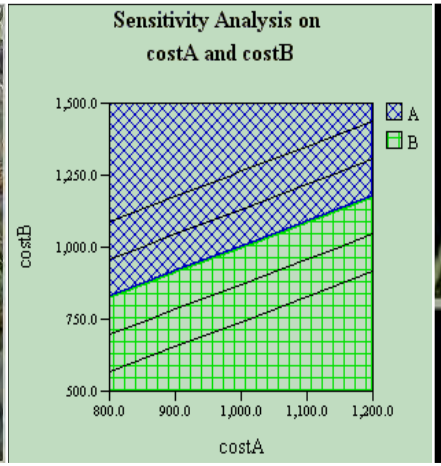
Within the United States civilian and military aviation system there are numerous crisis situations that occur each year that receive both local and national attention.

Process for Quantifying M&S

Document the Process and Results!

Adjust Throughout the Process!

Design Metrics



Quantitative - Relating to the measurement of quantity

Qualitative - A personal understanding that is based on qualities

Comparing Qualitative and Quantitative Methods

Foundational Similarities:

(1) All qualitative data can be measured and coded using quantitative methods.

(2) Quantitative metrics can be generated from qualitative inquiries.

Example: ***Comparison on Realism: How real does it look to you on a scale of 1-5?***

VS.

Foundational Differences:

(1) Difference between qualitative & quantitative research stems from underlying strategies.

(2) Quantitative research is viewed as confirmatory and deductive in nature.

(3) Qualitative research is considered to be exploratory and inductive.

Design Metrics

Remember the perspective of who the ROI is for.

Internal to the Program

Program Manager

Using Organizations

User

External to the Organization

Press

Other

Environmentalist

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Collect Data

Adjust Throughout the Process!

Collect Data
Training Example

Training Example – How do I prepare employees for an aviation incident /accident?

Collect Data Training Example

		Prior to the Simulation Exercise	Relook of Answers	Post Simulation Results
1	Our CRM plan addresses communications.			
2	I am prepared for a crisis situation.			
3	I make decisions with input from others.			
4	My actions would be consistent in a crisis.			
5	I would delegate during a crisis.			
6	I would keep focused through resolution.			
7	I know what questions to ask in a crisis.			
8	I know how to execute actions in a crisis.			
9	I understand the implications of the CRM system.			
10	Our procedures are well thought out.			
11	Contingencies are planned for.			
12	Our emergency response system is effective.			
13	I know how to take charge in a crisis.			
14	I am prepared to handle a crisis.			

Collect Data Training Example

Overall Resource Utilization

1. COMPONENT AIR FORCE	FY 2005 MILITARY CONSTRUCTION PROJECT DATA (computer generated)	2. DATE
3. INSTALLATION AND LOCATION: AVIANO AIR BASE, ITALY	4. PROJECT TITLE: PLIGHT SIMULATOR	
5. PROGRAM ELEMENT: 27596	6. CATEGORY CODE: 171-212	7. PROJECT NUMBER: ASHE986013
8. PROJECT COST ($000): 2.834		

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT	COST
PRIMARY FACILITY				1,926
FLIGHT SIMULATOR	SM	560	3,365	(1,884)
ANTI-TERRORISM/FORCE PROTECTION	SM	560	75	(42)
SUPPORTING FACILITIES				570
UTILITIES	LS			(166)
PAVEMENTS	SM	3,500	40	(140)
SITE IMPROVEMENTS	LS			(104)
COMMUNICATION SUPPORT	LS			(150)
PASSIVE FORCE PROTECTION	LS			(10)
SUBTOTAL				2,496
CONTINGENCY (5.0 %)				125
TOTAL CONTRACT COST				2,621
SUPERVISION, INSPECTION AND OVERHEAD (6.5 %)				170
TOTAL REQUEST				2,792
TOTAL REQUEST (ROUNDED)				2,834
EQUIPMENT FROM OTHER APPROPRIATIONS (NON-ADD)				(36,045.0)

10. Description of Proposed Construction: Construct facility with oversized door and removable panels for equipment change outs. Support space for admin. training support machinery and maintenance functions. Simulator room will have raised computer flooring, soundproofing, demolition, and all utilities required. Provide 15 cm (5.9") concrete pavements. Must comply with regional force protection standards.

11. REQUIREMENT: 1,349 SM ADEQUATE: 0 SM SUBSTANDARD: 157SM

PROJECT: Construct a new flight simulator facility. (Current Mission)

REQUIREMENT: Provide Flight Simulator facility to support aircrew training activities. The project must include adequate space for administration and records, classrooms, and other supporting spaces. AT/FP costs on this project are higher than standard DoD guidance due to stricter EUCOM force protection standards requiring screening from direct fire weapons.

CURRENT SITUATION: The current flight simulator is housed in one building with the classrooms and administrative spaces in separate portable buildings. The lack of an adequate base facility for this requirement represents a serious deficiency toward pilot readiness.

IMPACT IF NOT PROVIDED: Without this project, vital training requirements will continue to be performed in substandard conditions thus seriously compromising pilot readiness and mission in the Southern European Regions

ADDITIONAL: This facility is eligible for NATO funding. The NATO funded portion ($1M) provides for a two-ship facility. This US cost share provides the other two ships, 560 SM, for a complete four-ship facility. This project complies with space criteria outlined in AFH 32-1084, "Facility Requirements." Project requires US/Italian Mixed

Labor Hours

Time to Input Scenario into the Simulation

Item	Hours
Task 1	20
Task 2	10
Task 3	12
Task 4	4

Time to Create Scenario

Task 1	40
Task 2	20
Task 3	38
Task 4	10

One Time Exterior Digitization of an Airport

Task 1	142
Task 2	142
Task 3	121
Total	559 hours

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Collect Data

Analyze Data

Adjust Throughout the Process!

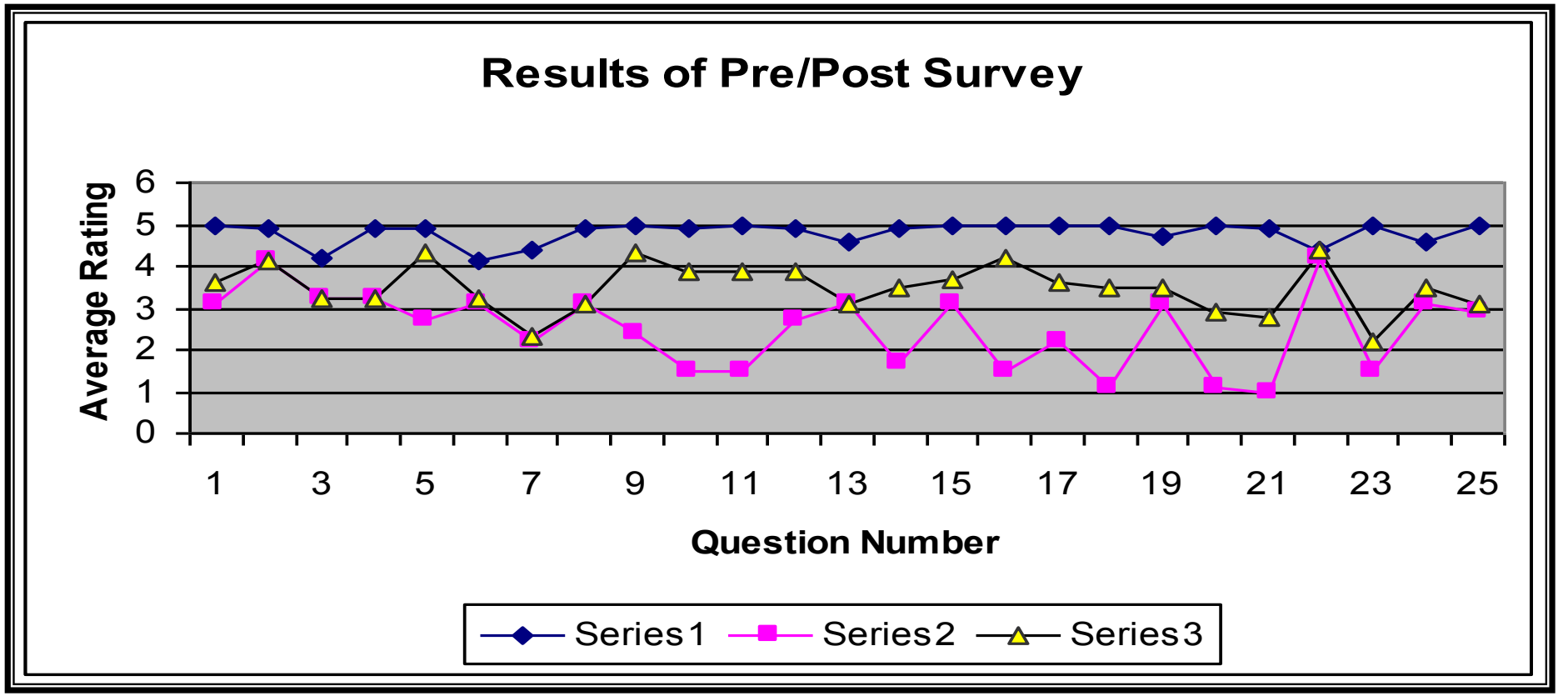
Analyze Data Training Example

Training Example – How do I prepare employees for an aviation incident /accident?

Analyze Data
Training Example

		Prior to the Simulation Exercise	Relook of Answers	Post Simulation Results
1	Our CRM plan addresses communications.	5	3.1	3.6
2	I am prepared for a crisis situation.	4.9	4.1	4.1
3	I make decisions with input from others.	4.2	3.2	3.2
4	My actions would be consistent in a crisis.	4.9	3.2	3.2
5	I would delegate during a crisis.	4.9	2.7	4.3
6	I would keep focused through resolution.	4.1	3.1	3.2
7	I know what questions to ask in a crisis.	4.4	2.2	2.3
8	I know how to execute actions in a crisis.	4.9	3.1	3.1
9	I understand the implications of the CRM system.	5	2.4	4.3
10	Our procedures are is well thought out.	4.9	1.5	3.9
11	Contingencies are planned for.	5	1.5	3.9
12	Our emergency response system is effective.	4.9	2.7	3.9
13	I know how to take charge in a crisis.	4.6	3.1	3.1
14	I am prepared to handle a crisis.	4.9	1.7	3.5

Analyze Data Training Example



Series 1 – Pre-simulation answers
Series 2 – Post simulation
Series 3 – 6 Months Post simulation
Line between points are to show a trend & do not indicate continuity

Analyze Data Training Example

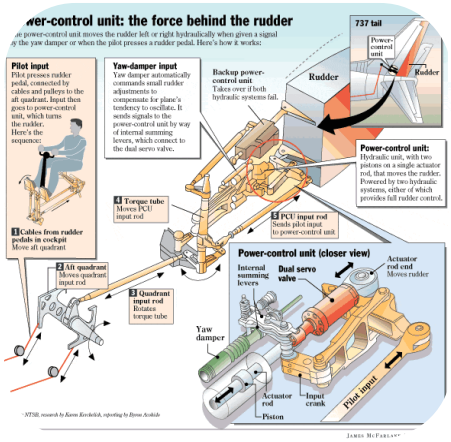
Actions to be Taken by the Staff Based on the Simulation Exercise:

Information was derived from multiple transcripts that were created from the videotaping of the simulation exercise sessions and after-action reviews.

- Modified crew hours and legs by year
- Changed crew activities during aircraft icing
- Increased awareness and information about bird strikes
- Changed procedures to avoid collision with ground vehicle
- Increased training with ground proximity warning system
- Developed scenarios to practice water landings
- Redefined CRM for medical issues & passenger disturbance
- Increased training for near midair collisions

Analyze Data Training Example

During one iteration of simulation runs and after-action review session, the various crews identified 38 actions that needed to be addressed.



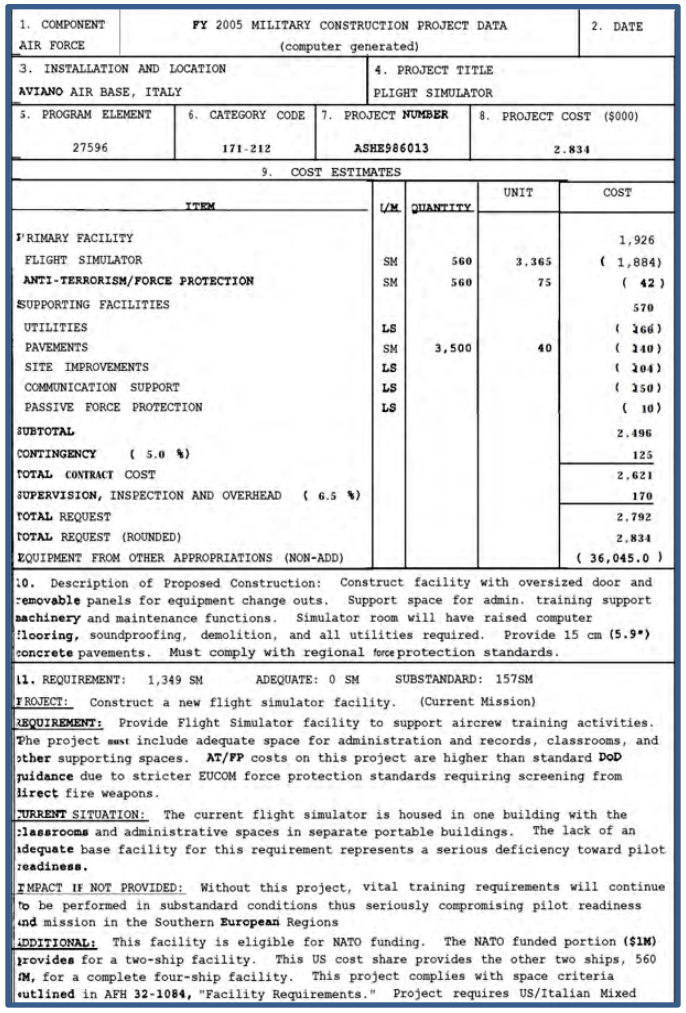
Actions ranged from a simple policy change to a complete revision of some aspects of CRM plans and procedures.

Example of one action - What technical information is available to assist both the crew and ground support advisors?

- Several crew members felt a number of informational items were distractors and unimportant.
- Ground controllers explained why items are extremely important—timing & location aspects .

Analyze Data Training Example

Overall Resource Utilization



1. COMPONENT	FY 2005 MILITARY CONSTRUCTION PROJECT DATA (computer generated)	2. DATE
AIR FORCE		

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
AVIANO AIR BASE, ITALY	FLIGHT SIMULATOR

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
27596	171-212	ASHE986013	2.834

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Time to Create Each Scenario

Item	Costs
Task 1 (40 hrs)	$2800
Task 2 (20 hrs)	$3000
Task 3 (38 hrs)	$1900
Task 4 (10 hrs)	$400
Total	$8100

One Time Exterior Digitization of an Airport

Item	Costs
Task 1 (142 hrs)	$18886
Task 2 (142 hrs)	$11502
Task 3 (121 hrs)	$8288
Total	$38316

Time to Input Scenario into the Simulation

Item	Costs
Task 1 (20 hrs)	$560
Task 2 (10 hrs)	$280
Task 3 (12 hrs)	$360
Task 4 (4 hrs)	$160
Total	$1360

Total Cost: $36,092,776

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Collect Data

Determine ROI

Analyze Data

Adjust Throughout the Process!

ROI Example - Training

Reuse

Multiple Configurations

Individual Trainer Configuration

Team Role Trainer

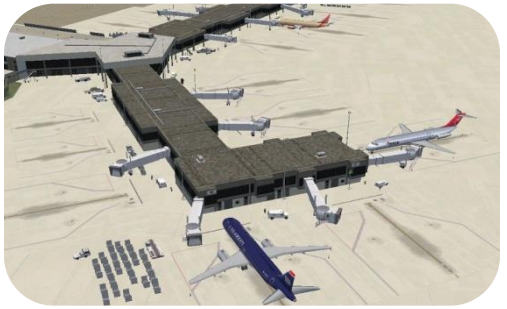
Seminar Configuration

Conference Configuration

Rehearsal Configuration

Situation Tool

Analysis Configuration



ROI Example - Training


Efficiency

VS.

- Efficiency for the 232,271 individuals in USA required to receive CRM training
  - 43,681 airline transport pilots
  - 78,670 flight attendants
  - 29,430 air traffic controllers
- Prior to 1998 CRM was optional for airlines
- FAA provided two methods for CRM training—classroom or simulator
- GAO - CRM just taught in a classroom without experiential experience is less effective
- Simulation can run any time
- Now FAA mandated training

450 Commercial Airports
Numerous Types of Commercial Aircraft
Each individual can be trained in their own environment

ROI Example - Training

Readiness

Effectiveness

During the one simulation and after-action review session, the staff identified 38 actions that needed to be addressed. All 38 were addressed which led to an additional 24 actions.

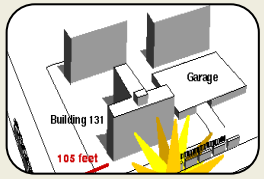
Actions ranged from a simple policy change to a complete revision of the plans.

- **Changed the notification to the press procedures**
- **Changed plan so that an emergency on an aircraft mobilizes the entire community**
- **Created a responsibility list for all administrators to follow while incident is occurring**
- **Changed procedures for dealing with passengers**
- **Further delineated responsibilities between pilots, flight attendants & air traffic controllers**

Over the last ten years since the FAA mandated simulation-based CRM training, there have been 382 reported incidents with only 12 incidents caused by improper use of CRM.

ROI Example - Training


Lives



Risk Reduction

Number of incidents and fatalities during the last ten years

Incidents	98	99	00	01	02	03	04	05	06	07	08	09	Total
Number	33	26	25	34	34	45	33	42	37	37	28	8	382
CRM Related Cause	0	2	0	3	1	1	1	0	2	1	0	1?	12
Fatalities	1	12	92	531	0	22	14	22	50	1	0	49	794
									% CRM Related				3%

–Everything that could go wrong on that flight to Buffalo on that wintery night did. We had a pilot who had not been trained on how to handle emergency procedures. He had never received simulator training for stall warnings, and reacted exactly opposite the way he should have, pulling back on the stick rather than pushing it forward to increase airspeed. It's a fatal mistake."

Former FAA Chief Michael Goldfarb

NSTB Hearing May 12, 2009 -Colgan Air, Inc. Flight 3407


2009 New York Crash

ROI Example - Training

American Airlines Example


Time


Money

Cost for a new simulator is $14 to $15 million	
14 different simulators	$126 million
107 simulator technicians and 8 engineers	$1.9 million per year Ten Years $19 million
Annual maintenance budget - $800,000	$800 thousand Ten Years $8 million
Ten-Year Costs	$153 million

ROI Example - Training

American Airlines Example

Time

Money

Simulators Usage 18 - 20 hours per day – 917,280 hours per year (2 positions per hour)

Train 9,000 American Airlines' pilot workforce

Re-certification at least every nine months

12 hours of simulation time per pilot

Over 10 years, 13 times per pilot – 156 hours

Required re-certification – 936,000 hours

Initial certification, changing seat or aircraft – 230,000 hours

Sell simulation time at $500 per hour; 100,000 hours – $50 million

ROI Example - Training

American Airlines Example

Time

Money

Ten Year Costs	$153 million

Per hour for a 737 – $2,200

Required re-certification – 268,000 flight hours

ROI
Per Year Savings
$179,600,000

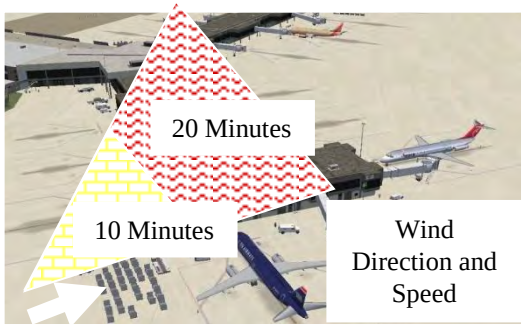
Initial certification, changing seat or aircraft – 115,000 flight hours

Total – 583,000 flight hours X $2,200 = $1,282,600,000

Overall ROI – $1,282,600,000 – $103,000,000 (less $50M) = $1,179,600,000

ROI Example - Training

Situation Tool



Environment

Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Collect Data

Analyze Data

Determine ROI

If Needed, Initiate Corrective Action

Adjust Throughout the Process!

Contents of an ROI Evaluation Plan

Document the Process and Results!

- Title Page
- Table of Contents
- Executive Summary
- Purpose of the Report
- Background of the Simulation Being Evaluated
- Methodology for Conduct of the ROI
- Baseline Data Point
- Metrics
- Outcomes and Performance Measures
- Staffing
- Data
- Data Analysis
- Interpretations and Conclusions
- Recommendations


CAUTION
WATCH
YOUR STEP

Other ROI Aspects
Unknown Secondary Effects

Dating

Social Systems

Invention of Computer

Shopping

Effect on Commerce

Identity Theft

Individual Freedom

Basic Math Skills

Mutual Dependence

Any Questions?

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